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DENVER
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MARTIN COMPANY

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Copy No. 16
13 May 1963

Refer to: 3-Y-50,844

To: Space Technology Laboratories
One Space Park
Redondo Beach, California

Attn: Titan II Program Office

CC: To all holders of subject document

Subj: Contract AF04(694)-213, CR-63-114, Post Firing Captive
Test Report, MVF, SM68B-27

Ref: Paragraph 3.11.3 of contractor's specification BMS-TII-
CD-74,000 dated 30 December 1960, SCNs 1 thru 13, as in-
corporated in Item 8 of Exhibit A of subject contract by
Exhibit E as a part of AFBM Exhibit 58-1

Encl: CR-63-114

1. In accordance with contractual requirements of the above
reference, copies of the subject document are transmitted herewith.

Very truly yours,

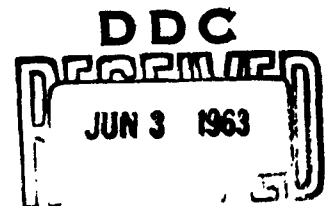
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Bureau of the Budget
Approval No. 21-R138.1

THE AEROSPACE
DIVISION OF
MARTIN
MARIETTA

POST FIRING CAPTIVE TEST REPORT

Missile SM68B-27

Missile Verification Firing

CR-63-114

1.0 INTRODUCTION

- 1.1 This is a summary of Missile Verification Firing (MVF) of Missile B-27 performed by the Martin Company at the Denver Test Stand D-2 in accordance with Test Directive MVF B-27.

2.0 MISSILE CHECKOUT AND MVF DESCRIPTION

2.1 Missile Configuration

Missile B-27 was in an operational configuration.

Airborne batteries were not used for the MVF.

A.C. Guidance System was simulated.

Flight engines were installed. (This was the first Stage II flight engine to be test fired at Martin-Denver.)

2.2 Chronological History

Missile B-27 was delivered to Test Stand D-2 on 29 March 1963. Missile erection was completed 1 April 1963.

Power application was delayed due to the necessity of repairing missile umbilical plug 3BlE. Three umbilical pins were found to be damaged (scratched). The position where this damage was incurred is unknown. However, all test positions where the umbilicals are mated received a through inspection. Ground pins are being changed to the latest "bullet" configuration.

The gas generators were removed and returned to AGC, Sacramento, for inspection prior to the missile arriving on the test stand. Stage I gas generators were removed for a "deburring" operation and the Stage II gas generator was inspected for contamination.

The Stage I & II gas generators were received from AGC and were installed and retested on 8 April 1963.

The umbilical plug (3BlE) rework was completed 5 April 1963. Initial application of ground power was made at this time.

An MFL check was attempted on 5 April 1963. A "Hold" was encountered due to low reservoir level on Stage I. The Stage I hydraulic system was refilled, bled and sealed. A second MFL check was conducted and a "hold" was encountered due to low reservoir level on Stage II. The Stage II hydraulic system was refilled, bled and sealed. These hydraulic systems problems were a result of improper relief valve setting. The return relief valve setting was not increased prior to the initial hydraulic fill and seal test. The result was a poor fill and seal. Another MFL check was conducted upon the completion of an acceptable fill and seal on both hydraulic systems and a "Hold" was encountered (replace autopilot). After extensive troubleshooting the problem was traced to slow response (ringing) of the 2₂ vernier actuator. The actuator was replaced on 8 April 1963 and a successful MFL run was conducted.

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A CST (Combined Systems Test) was conducted 9 April 1963. The CST was unsuccessful due to low hydraulic reservoir level on Stage I. The Stage I hydraulic system was refilled, bled and sealed. A shredded "O" ring was found in the hydraulic relief tool which allowed leakage. This "O" ring was replaced prior to filling and sealing the hydraulic system.

A subsequent MFL test was conducted 9 April 1963 to retest the hydraulic system. A "Hold" (replace autopilot) was again encountered. This problem was again found to be the 2₂ vernier actuator slow response (ringing) problem. This actuator was replaced and the hydraulic system refilled, flushed, bled and sealed. (See action items for problem analysis).

The official CST was conducted on 10 April 1963. Minor instrumentation problems were encountered and resolved.

Ordnance was installed and propellants were loaded on 11 April 1963. Propellants were loaded in three hours.

On 12 April 1963 during the precountdown checks the Stage II pre valves opened inadvertently and an oxidizer leak developed on the Stage II engine. A small fire occurred on the Stage II deflector plate due to the oxidizer leak and the normal overboard flow of fuel through the PSV. The pre valves were closed and the fire extinguished using the normal emergency procedures. All propellants were subsequently unloaded and ordnance was disconnected.

Investigation revealed that the Stage II pre valves were opened inadvertently when a bulb verification was performed on the MCS. A shorted (blocking) diode allowed the bulb verification power to feed back through the master sequencer to the pre valve opening circuit. This circuit is peculiar to Test Stand D-2 and is not used at operational bases. The normal airborne pre valve opening circuit cannot be utilized for a captive firing (short duration) due to the propellant bleed in time requirements.

The shorted diode was replaced and other circuits were checked and analyzed for similar circumstances. Procedures were modified to prevent this problem from reoccurring. Circuit design changes are now being contemplated to interlock this and similar type circuits to prevent any reoccurrence.

The oxidizer leak was isolated to the Stage II engine oxidizer pump seal. The leak was of a magnitude that required the replacement of the pump seal. The Stage II TPA was removed 13 April 1963 and returned for repair. The TPA was returned, reinstalled and leak checked on 15 April 1963. (See Quick Look Action Items for additional information).

A turbine pump shaft lock washer inspection (ETD 7.81) was performed on the Stage I engine 12 April 1963.

The Stage II airborne hydraulic system was refilled, flushed, bled and sealed after the turbine pump assembly was reinstalled.

An official CST was conducted on 16 April 1963, in which two problems appeared.

- (1) Actuator 7₂ was fluctuating. The problem was traced to a missing washer which AGC personnel neglected to install during the installation of the roll control assembly. This was corrected by installing the washer.
- (2) Measurement 3440 (VEPS power) did not play. This problem was the result of improper recorder operation.

Ordnance was installed and propellant loading was completed on 17 April 1963.

The countdown was initiated and successfully completed on 17 April 1963. Fire Switch 87FS1 occurred at 10:44:06. Both Stage I and Stage II fired for the planned 20 sec. duration.

A vernier gimbal system test was performed on the vernier actuators on 19 April 1963. This test was to verify the breakaway torque of the actuators during static conditions and is being used for engineering analysis.

Post firing inspection revealed a small amount of corrosion in umbilical 3B1E. This corrosion was due to a potting deficiency (a small cavity existed near one pin). The defective potting was removed and replaced.

Missile decontamination and cleaning was delayed due to the faulty operation of the AGC V-96 unit.

The missile was de-erected and returned to the factory 25 April 1963.

The Quick Look meeting was held on 19 April 1963 and resulted in the following action items.

A. Problem

Leakage of the Stage II Oxidizer pump seal.

A leak check was performed on the above seal during Phase 01 checkout. This leak test was performed subsequent to the breakaway and running torque test. Test results was zero leakage.

The Stage II prevalues were inadvertently opened. A large oxidizer leak was noted in the vicinity of the Stage II TPA. Propellants were off-loaded and the leak investigated. A leak of 4000 cc/min was located at the oxidizer pump seal. The turbo pump oxidizer cavity purge (TPOCP) was on for approximately nine hours prior to the prevalue opening.

A heated purge was applied to the TPOCP and the turbine was rotated to see if the leakage rate would decrease. Instead the leakage rate increased to 10,000 cc/min.

The Stage II TPA was removed and the oxidizer pump cavity seal was replaced. The original seal was found to be seated correctly with no evidence of damage to the seal; however, the running ring was found to be scored.

The above seal was checked at Engine Preparation prior to installation in Missile B-27. This test also indicated zero leakage.

Action Item

Investigate the pump seals to determine:

1. Cause of leakage.
2. Corrective action.

Report

1. The pump seal leakage problem seems to be the result of a crystalline deposit which is a residue from propellants, neutralizer or a combination of both. This deposit seems to have a build up rate in proportion to time. This crystalline deposit damages the seal running ring when the pump is rotated. Aerojet is presently attempting to analyze this deposit and create corrective action. Procedures were modified to minimize TPOCP purge time.

Report - continued

2. The corrective action now in current operation is to replace the pump seals as required.

B. Problem

Vernier actuator "ringing" and MFL incompatibility.

Two vernier actuators were replaced on Missile B-27 due to excessive "ringing". Data indicates these actuators were moving off and on the gain land for as much as 1.4 seconds.

MFL timer A2 (P/C board A9 of E2302) was found to be timing out at 0.4826 seconds. This is the time delay to allow the vernier actuator response time prior to being checked. Modification TO 3843-09 changed the time requirement of timer A2 from 0.50 sec to 0.75 sec in the Test Specifications only. A physical change of this timer was not accomplished on Mod. TO 3843. P/C board A9 of E2302 was changed to a 0.75 sec timer.

Action Item

- (1) Investigate vernier actuators for oscillations ("ringing") in excess of specifications.
- (2) Investigate modification TO 3843 for proper equipment replacement requirements.

Report

1. The two rejected vernier actuators have been sent to the Hydraulics Lab for failure analysis. The analysis has not been completed at this time. A true criteria for what constitutes excessive "ringing" has never been defined with respect to flight dynamics. Flight Controls Design Analysis Group is presently researching this problem to ascertain if the setting for MFL timer A2 is a realistic criteria.
2. The A2 timer is an adjustable timer (0.1 sec to 1.4 sec). To change the timer setting, it is necessary to adjust resistor R9 in accordance with the instructions contained within Test Specification 804E23020256. This test specification was included as an integral part of Mod. TO-3843-09 and should have been accomplished with no equipment replacement.

C. Problem

Shorted diode in the MCS (Master Sequencer). A shorted diode in the MCS resulted in a signal being sent to open the Stage II pre valves when "bulb verification" was performed.

Action Item

Investigate similar circuits for identical conditions. Analyze all control circuits for potential problem areas.

Report

Procedures have been modified to prevent the recurrence of this problem as pertains to the master sequencer. Circuitry changes are being made which will isolate the Stage II pre valve ordnance circuit. Operational ground equipment is being investigated by Systems Engineering in order to prevent similar experiences with the operational weapon system.

3.0 TEST SPECIFICATIONS

The test objectives specified in the Test Specification - General Missile, SM68B, Print No. 804B9000100 and the degree to which they were accomplished are listed as follows:

3.1 Primary Objectives.

3.1.1 Demonstrate proper operation and compatibility of the complete missile system with OGE under a firing environment, within the capabilities of the Denver test area.

3.1.1.1 The OGE, with the exception of the MFL, performed satisfactorily throughout the checkout, countdown and firing. The MFL problem associated with "ringing" actuators is explained under Quick Look Action Items. The MFL performed as designed but a question has been brought up as to the correct adjustment of the A2 timer. This is presently being worked by engineering.

Objective was met.

3.1.2 Verify adequate manufacturing quality of the operational missile.

3.1.2.1 Manufacturing quality of the missile was adequate throughout the firing.

Objective was met.

3.1.3 Provide problem information covering all aspects of missile and OGE checkout and operation so that problems can be identified and action can be initiated to resolve them at the earliest possible point in the program.

3.1.3.1 Trouble Reports and Failure Reports were prepared as necessary. Test stand personnel have submitted the formal Problem Summary Report.

3.1.4 Verify adequate manufacturing quality of the airframe to support missile firings and to withstand the hot firing environment.

3.1.4.1 Post firing inspections and leak checks substantiate the fact that planned firing duration was achieved without leakage of propellant tanks or associated lines or material failure of the basic structure.

Objective was met.

3.1.5 Verify that the quality and performance of the engines are in no way degraded by processes and procedures performed after engine acceptance tests.

3.1.5.1 Operation of the engines throughout the MVT were within limits as specified in "Test Specification - Guided Missile, SM68B".

3.1.6 Verify that manufacturing quality of the missile propellant feed and autogenous pressurization subsystems meet design requirements.

3.1.6.1 The propellant feed system and autogenous pressurization system met all objectives during the MVT of Missile B-27.

Objective was met.

3.1.7 Verify proper operation of the flight control subsystem under firing conditions.

3.1.7.1 The actuator gimbaling occurred as planned. All flight control parameters remained in limits as specified.

Objective was met.

3.1.8 Demonstrate the functional compatibility of the OGE with the missile.

3.1.8.1 All automatic checkouts, countdown and firing were completed without holds or malfunctions caused by OGE incompatibility with the possible exception of the MFL. This problem is reported under Quick Look Action Items.

3.1.9 Verify satisfactory operation of the missile electrical system during MVP operation.

3.1.9.1 Data obtained during the MVP indicated all electrical subsystems performed within specification.

Objective was met.

4.0 SECONDARY OBJECTIVE


4.1 Obtain data for use in determining missile reliability.

4.1.1 Trouble Reports, Failure Reports, Problem Reports and Test Stand Operation Records have been submitted for missile reliability study.

5.0 CONCLUSIONS:

5.1 The MVP of Missile SM68-B27 was successful.

5.2 Missile B-27 contained the first Stage II flight engine to be test fired at Martin-Denver. The engine performed satisfactorily during the "Hot" firing; however, excessive leakage (pump seal) was experienced prior to the MVP. A conclusion cannot be drawn regarding the reliability of the Stage II engine pump seals due to the minimal amount of testing which has been conducted.


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